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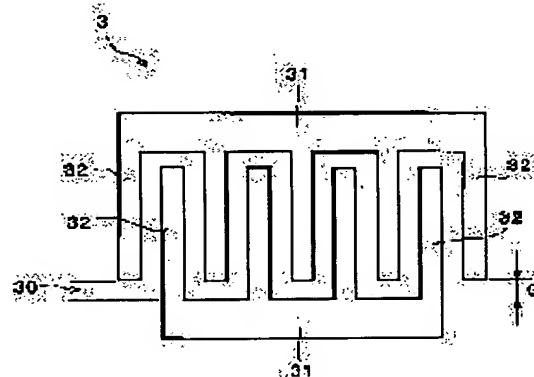
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(54) SURFACE ACOUSTIC WAVE FILTER, SURFACE ACOUSTIC WAVE DEVICE AND COMMUNICATION EQUIPMENT**(57)Abstract:**

PROBLEM TO BE SOLVED: To provide a high quality vertically coupled resonator surface acoustic wave filter having an excellent filter characteristic by improving flatness in the pass band.

SOLUTION: A turned Y-cut X propagation LiTaO₃ board is used as a piezoelectric board, and a gap length G in an IDT electrode 3 constituting a surface acoustic wave resonator is made as ≤ 0.3 times as long as the wavelength λ of a surface acoustic wave ($0.3\lambda \geq G$). The gap length G is an interval between a pair of bus bars 31 constituting the IDT electrode 3 and a plurality of electric fingers 32,... extending from the bus bars 31 in a facing direction.

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CLAIMS

[Claim(s)]

[Claim 1] It has two or more electrode fingers extended toward the opposite direction from the electrode terminal and each electrode terminal of the couple which counters mutually. The INTADIJITARU transducer electrode which forms the configuration where made these two or more electrode fingers cross, respectively, and each other were engaged In the surface acoustic wave filter of the vertical joint resonator mold which carries out contiguity arrangement along the propagation direction of a surface acoustic wave, and equips the both sides with two or more surface acoustic wave resonators which come to arrange the reflective structure further on a piezo-electric substrate It is the revolution Y cut X propagation LiTaO3 as the above-mentioned piezo-electric substrate. While using a substrate The surface acoustic wave filter characterized by materializing the relation of $0.3 \lambda \geq G$ when spacing of the head of the above-mentioned electrode finger which one electrode terminal has, and the electrode terminal of another side which counters this is set to gap length G and wavelength of the above-mentioned surface acoustic wave is set to λ .

[Claim 2] The above-mentioned electrode terminal is a surface acoustic wave filter according to claim 1 characterized by having two or more dummy electrode fingers formed so that the above-mentioned electrode finger extended from the other party's electrode terminal may be countered by projecting toward the above-mentioned opposite direction further.

[Claim 3] Surface acoustic wave equipment characterized by having a surface acoustic wave filter according to claim 1 or 2.

[Claim 4] The communication device characterized by using a surface acoustic wave filter according to claim 1 or 2 or surface acoustic wave equipment according to claim 3.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to a communication device at a surface acoustic wave filter and surface acoustic wave equipment equipped with this, and a list, and is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate especially. It is related with a surface acoustic wave filter, and the surface acoustic wave equipment and the communication device using this of the vertical joint resonator mold using a substrate.

[0002]

[Description of the Prior Art] A surface acoustic wave filter is a filter containing the surface acoustic element using the surface acoustic wave spread along a piezo-electric substrate front face, for example, is used for various applications prepared in a RF circuit, such as a surface acoustic wave filter, in mobile communications commercial scenes, such as a cellular phone.

[0003] Especially, since wavelength is short compared with an electromagnetic wave, the above-mentioned surface acoustic wave has the advantage of being easy to miniaturize surface acoustic wave equipment equipped with a surface acoustic wave filter itself. Therefore, in the field of communication devices, such as the above-mentioned cellular phone with which recent years more much more miniaturization and low back-ization are called for, the need of the above-mentioned surface acoustic wave filter or surface acoustic wave equipment is also very large.

[0004] Here, also in the above-mentioned surface acoustic wave filter, since especially the surface acoustic wave filter (it abbreviates to a vertical joint mold filter hereafter) of a vertical joint resonator mold can respond to low loss and a RF, its surface acoustic wave filter is in use.

[0005] As a concrete technique about such a vertical joint mold filter, the vertical joint dual mode surface acoustic wave filter currently indicated by JP,5-267990,A, for example is mentioned.

[0006] The vertical joint mold filter of the above-mentioned technique carries out contiguity arrangement of the three INTADIJITARU transducer electrodes (IDT electrode) along the propagation direction of a surface acoustic wave on a piezo-electric substrate, and has the configuration which arranges a reflector on the both sides further. And each IDT electrode limits spacing of the center to center of the electrode finger of the innermost part which counters mutually on the basis of the wavelength λ of a surface acoustic wave. Consequently, it is possible to be able to realize the fractional bandwidth which reaches to 4%, even if it is a RF field near 1GHz, and to also make loss low.

[0007] By the way, although there are various things according to the application of this filter as a property required of a vertical joint mold filter including the technique of the above-mentioned official report, the filter for RKE(Remote Keyless Entry System) RF requires the property (narrow-band property) used as a narrow band especially, for example so that it can respond to necessary pass band width. In the former, in order to realize the above-mentioned narrow-band property to the vertical joint mold filter of this application, the Xtal substrate which has a zero temperature coefficient has been used as a piezo-electric substrate.

[0008] However, since the above-mentioned Xtal substrate has a low dielectric constant, an electromechanical coupling coefficient is also small and the impedance of the filter itself becomes high, a matching circuit is needed separately to a vertical joint mold filter. So, with the above-mentioned configuration, the inconvenient point in respect of [, such as complication of a configuration or an increment in components mark,] manufacture had arisen. And since loss became large, with the above-mentioned configuration, inconvenience had produced the vertical joint mold filter obtained also in respect of quality.

[0009] Then, in order to realize the above-mentioned narrow-band property recently, it is the revolution Y cut X propagation LiTaO₃ especially as a piezo-electric substrate. The substrate is used more often. This revolution Y cut X propagation LiTaO₃ As compared with what used the Xtal substrate, low impedance-ization of the vertical joint mold filter using a substrate is attained, and it is possible to control the above-mentioned inconvenience.

[0010]

[Problem(s) to be Solved by the Invention] However, it is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. If the vertical joint mold filter using a substrate tends to realize the above-mentioned narrow-band property, the trouble that surface smoothness worsens shortly will be produced.

[0011] As shown in drawing 10 , with the conventional vertical joint mold filter, the wave of a passband tapers off and, specifically, it has become a configuration (drawing Nakaya mark). Therefore, the ripple deflection used as the index of the surface smoothness in a passband gets worse, and the trouble that the width of face of a passband becomes narrow beyond the need is produced. In addition, the phenomenon in which the width of face of a passband becomes narrow beyond the need is made into a superfluous narrow-band-ized phenomenon.

[0012] This invention is made in view of the above-mentioned trouble, and the object is in offering a surface acoustic wave filter, and the surface acoustic wave equipment and the communication device using this of the quality vertical joint resonator mold which has the good filter shape which raised the surface smoothness in a passband further.

[0013]

[Means for Solving the Problem] this invention persons set in the surface acoustic wave filter of a vertical joint resonator mold, as a result of inquiring wholeheartedly, in order to cancel the above-mentioned trouble. As a piezo-electric substrate, it is the revolution Y cut X propagation LiTaO₃. While using a substrate If spacing of the electrode finger which constitutes an IDT electrode, and the bus bar (electrode terminal) which counters this electrode finger is specified in the predetermined range based on the wavelength λ of a surface acoustic wave The surface smoothness in a passband improves and it came to complete a header and this invention for a good filter shape being realized uniquely.

[0014] Namely, the surface acoustic wave filter concerning this invention In order to solve the above-mentioned technical problem, it has two or more electrode fingers extended toward the opposite direction from the electrode terminal and each electrode terminal of the couple which counters mutually. The INTADIJITARU transducer (IDT) electrode which forms the configuration where made these two or more electrode fingers cross, respectively, and each other were engaged In the surface acoustic wave filter of the vertical joint resonator mold which carries out contiguity arrangement along the propagation direction of a surface acoustic wave, and equips the both sides with two or more surface acoustic wave resonators which come to arrange the reflective structure further on a piezo-electric substrate It is the revolution Y cut X propagation LiTaO₃ as the above-mentioned piezo-electric substrate. While using a substrate When spacing of the head of the above-mentioned electrode finger which one electrode terminal has, and the electrode terminal of another side which counters this is set to gap length G and wavelength of the above-mentioned surface acoustic wave is set to λ , it is characterized by materializing the relation of $0.3\lambda \geq G$.

[0015] As a result of this invention persons' inquiring uniquely, it was considered to be the cause that the level of resonance mode decreased aggravation of the above-mentioned surface smoothness and generating of the superfluous narrow-band-ized phenomenon accompanying this under the effect of SSBW (Surface Skimming Bulk Wave) generated in the gap field between the head of the above-mentioned electrode finger and an electrode terminal (bus bar). It is known that this SSBW will be strongly emitted in the free surface. Therefore, if the non-exciting field which is equivalent to the free surface in an IDT electrode is made small, it will become possible to suppress generating of SSBW.

[0016] Then, according to the above-mentioned configuration, the wavelength λ of a surface acoustic wave is shorter than 0.3 times, and gap length G which is spacing of the head of the above-mentioned electrode finger and an electrode terminal is carried out. Therefore, since the non-exciting field (gap field) equivalent to the above-mentioned free surface can be made small, it becomes possible to suppress generating of Above SSBW. Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the surface acoustic wave filter which has a high filter shape can be obtained.

[0017] In addition to the above-mentioned configuration, the surface acoustic wave filter concerning this invention is characterized by having two or more dummy electrode fingers formed so that the above-mentioned electrode finger

extended from the other party's electrode terminal when the above-mentioned electrode terminal projects toward the above-mentioned opposite direction further may be countered.

[0018] According to the above-mentioned configuration, it becomes possible by forming a dummy electrode finger to suppress generating of Above SSBW further so that the above-mentioned electrode finger may be countered.

Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the surface acoustic wave filter which has a still higher filter shape can be obtained.

[0019] The surface acoustic wave equipment concerning this invention is characterized by having the surface acoustic wave filter of the above-mentioned configuration.

[0020] Moreover, the communication device concerning this invention is characterized by using the surface acoustic wave filter of the above-mentioned configuration, or the surface acoustic wave equipment of the above-mentioned configuration.

[0021] According to each above-mentioned configuration, since it has the surface acoustic wave filter of high quality, the function as surface acoustic wave equipment or a communication device can be raised further.

[0022]

[Embodiment of the Invention] [Gestalt 1 of operation] It will be as follows if the gestalt of operation of the 1st of this invention is explained based on drawing 1 thru/or drawing 7. In addition, this invention is not limited to this.

[0023] The surface acoustic wave filter concerning this invention is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. On a substrate Have the resonator which has two or more INTADIJITARU transducer (IDT) electrodes and the reflective structure arranged so that this may be pinched. When wavelength of a surface acoustic wave is set to λ , gap length G between the head of two or more electrode fingers which are the surface acoustic wave filters (vertical joint mold filter) of a vertical joint resonator mold, and the above-mentioned IDT electrode has, and the electrode terminal (bus bar) which counters it It sets up so that the relation of $0.3 \lambda \geq G$ may be materialized.

[0024] Moreover, the surface acoustic wave equipment concerning this invention is equipped with the surface acoustic wave filter of the above-mentioned configuration.

[0025] Specifically, for the vertical joint mold filter [in / as shown in drawing 2 / the gestalt of this operation] 1, the surface acoustic wave resonator 5 (it only considers as a resonator hereafter) which becomes two or more IDT electrode 3 -- from the reflector (reflector) 4-4 of a couple is LiTaO₃. It has composition formed on [two] the substrate 2. In addition, a reflective end face may be used instead of a reflector. Namely, the reflective structure of a wide sense should just be used.

[0026] Contiguity arrangement of three IDT electrode 3a, 3b, and the 3c is carried out, and the above-mentioned resonator 5 has the composition that the reflector 4-4 of a couple is arranged to these ends. The direction where three IDT electrode 3a, 3b, and 3c are arranged is a direction which met in the propagation direction of the surface acoustic wave in the above-mentioned vertical joint mold filter 1. Moreover, since it is arranged so that above-mentioned IDT electrode 3a, 3b, and 3c may be pinched, the reflector 4-4 will be arranged along the propagation direction of a surface acoustic wave like the orientation of IDT electrode 3a, 3b, and 3c.

[0027] With the gestalt of this operation, among three above-mentioned IDT electrode 3a, 3b, and 3c, the end of IDT electrode 3a and 3c is grounded, and the signal terminal 7 is formed in IDT electrode 3b.

[0028] In the above-mentioned vertical joint mold filter 1, the direction where the resonator 5-5 is arranged is a direction (lengthwise direction) which intersects perpendicularly in the propagation direction of the above-mentioned surface acoustic wave. And cascade connection of between resonators 5-5 is done by the connection 6 between each IDT electrode 3a, 3b, and 3c. Therefore, the vertical joint mold filter 1 of the above-mentioned configuration has the so-called two-step composition. In addition, the joint capacity formed with the ctenidium-like electrode so that the above-mentioned connection 6 could take adjustment of interstage may have composition connected so that it may become parallel electrically with the above-mentioned IDT electrode 3, and it is not limited especially.

[0029] In addition, as a configuration of the above-mentioned vertical joint mold filter 1, it is not limited to the above-mentioned two-step configuration. For example, you may be what formed one resonator 5 and made the connection number of stages one step, i.e., the thing of a single stage configuration, and may be what prepared three or more resonator 5 --, i.e., the thing of three or more steps of multistage configurations. Moreover, between each resonator 5-5, the connection method of interstage is not limited to the above-mentioned approach, either, and may be changed into

other connection methods.

[0030] In drawing 2, although each IDT electrode 3a, 3b, and 3c are illustrated typically, it has the composition of having two or more electrode finger (excitation electrode finger) 32 -- extended toward the bus bar (electrode terminal) 31-31 and each bus bar 31 of the couple which counters mutually as it is shown in drawing 1, when a configuration is illustrated more concretely to the opposite direction of these IDT(s) electrode 3 --. Two or more above-mentioned electrode finger 32 -- crosses, respectively, and has become the configuration which was engaged mutually.

[0031] The logarithm of one pair, then the electrode finger 32-32 which constitutes the IDT electrode 3 is suitably set up according to the demand characteristics of the vertical joint mold filter 1 in the combination of the electrode finger 32-32 per piece extended, respectively from each bus bar 31-31 which counters. Similarly, the width of face (decussation width of face) which each electrode finger 32 extended, respectively intersects is suitably set up according to demand characteristics from the bus bar 31-31 which counters.

[0032] Furthermore, by this invention, as shown in drawing 1, when spacing of the head of the above-mentioned electrode finger 32 and the bus bar 31 which counters this is set to gap length G and this gap length G sets wavelength of a surface acoustic wave to λ , it is specified that the relation of $0.3\lambda \geq G$ is materialized.

[0033] It is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. With the vertical joint mold filter using a substrate, if it is going to realize a narrow-band property, the superfluous narrow-band-ized phenomenon which surface smoothness worsened, therefore was mentioned above will arise. This superfluous narrow-band-ized phenomenon is a gap field between the head of the above-mentioned electrode finger, and a bus bar, and is considered for SSBW (Surface Skimming Bulk Wave) to occur. That is, SSBW is the effect generated in the above-mentioned gap field, and it is for the level of resonance mode to decline.

[0034] It is known that Above SSBW will be strongly emitted in the free surface. Then, in an IDT electrode, it is making small the non-exciting field equivalent to the above-mentioned free surface, and it becomes possible to suppress generating of Above SSBW.

[0035] Here, as shown in drawing 1, the gap field 30 between the head of the electrode finger 32 in the IDT electrode 3 and the bus bar 31 which counters it is excitation with the free surface which has not contributed. So, if the above-mentioned gap length G is shortened, since the gap field 30 will become narrow, a non-exciting field can be made small. Consequently, the surface smoothness in a passband can be improved and it becomes possible to prevent a superfluous narrow-band-ized phenomenon.

[0036] When the correlation with the above-mentioned gap length G, the deflection in a band (ripple deflection), and the width of face (bandwidth) of a passband was acquired, wavelength of a surface acoustic wave was set to λ and the above-mentioned gap length G was actually specified below to 0.3λ so that clearly from the example mentioned later, it was found out that the deflection in a band and bandwidth are improved. The above-mentioned ripple deflection is the index of surface smoothness, and it becomes good [surface smoothness], so that this value is small. In this invention, when it prescribed that gap length G became $0.3\lambda \geq G$, it turned out that ripple deflection is improved and bandwidth also becomes large.

[0037] In addition, although, as for gap length G, only 0.3λ is specified as an upper limit and the minimum is not specified, the above-mentioned gap length G is that which points out spacing of the head of the electrode finger 32, and a bus bar 31, and always exceeds 0 until it gets tired ($G > 0$), and this is because it is not necessary to limit a minimum.

[0038] That is, in this invention, the lower limit of gap length G will be equivalent to the threshold value on the process at the time of forming the above-mentioned IDT electrode 3 to the upper limit of gap length G being 0.3λ . For example, as an approach of forming the IDT electrode 3, although the wet etching method can generally be used, it is also possible to use the dry etching method. At this time, the threshold value of gap length G obtained by the dry etching method becomes smaller than the threshold value of gap length G obtained by the wet etching method.

Therefore, the minimum of gap length G serves as threshold value of the process which forms the IDT electrode 3.

[0039] In this invention, further, as shown in drawing 3, the IDT electrode 3 has projected toward the above-mentioned opposite direction, and may have two or more dummy electrode finger 33 -- formed so that the above-mentioned electrode finger 32 extended from the other party's bus bar 31 may be countered. That is, the dummy electrode 33 will be formed so that it may project from a bus bar 31 to the gap field 30 which is a non-exciting field.

[0040] Thus, if the dummy electrode finger 33 which counters the above-mentioned electrode finger 32 is formed, it is possible to be able to avoid aggravation of the above-mentioned surface smoothness much more certainly, and to prevent generating of a superfluous narrow-band-ized phenomenon more effectively so that clearly from the example

mentioned later.

[0041] In addition, gap length G in case there is a dummy electrode finger 33 shall point out spacing from the head of the electrode finger 32 to the head of the dummy electrode finger 33 which counters it, as shown in drawing 3. So, the die length of the dummy electrode finger 33 is a design matter chosen suitably, and is not especially limited by the size of above-mentioned gap length G and the IDT electrode 3 etc.

[0042] At this invention, it is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. A substrate 2 is used. This revolution Y cut X propagation LiTaO₃ As a substrate 2, it is not especially specifically limited. At the example mentioned later, it is the revolution Y cut X propagation LiTaO₃. Although the thing of 36-degree revolution Y cut X propagation is used, even if cut angles other than this are used for the cut angle of a substrate 2, since the difference in physical properties does not participate in radiation of SSBW, it can acquire the same effectiveness.

[0043] [Example] A convention of the above-mentioned gap length G in the gestalt of this operation is more concretely explained based on the following examples. In addition, this example is an example for specifying the above-mentioned gap length G , and this invention is not limited to this example.

[0044] The vertical joint mold filter 1 (refer to drawing 2) of the two-step configuration mentioned above is mentioned as an example, and this example explains it. The fundamental configuration of the vertical joint mold filter 1 used by this example is as follows.

[0045] That is, center frequency used as the center of the passband in the vertical joint mold filter 1 was first set to 298MHz. Moreover, as a piezo-electric substrate, it is the 36-degree revolution Y cut X propagation LiTaO₃. The substrate 2 was used. Electrode layer thickness was set to 400nm, using an aluminum-Cu alloy as an electrode material. As for each concrete configuration of the above-mentioned reflector 4, the number set wavelength to 13.82 micrometers by 41. Moreover, the logarithm of the electrode finger 32-32 in three IDT electrode 3a, 3b, and 3c shown in drawing 2 formed the concrete configuration of the above-mentioned IDT electrode 3 so that it might become 17 pairs, 22 pairs, and 17 pairs, respectively.

[0046] next, with the vertical joint mold filter (this invention mold filter) concerning this invention used by this example, when wavelength of a surface acoustic wave is set to λ , it becomes below 0.3λ about gap length G ($0.3\lambda \geq G$) -- it has set up small like. Furthermore, in this example, the conventional vertical joint mold filter (conventional-type filter) which does not set up gap length G small is also used as usual for the comparison. Although the fundamental configuration is the same as this invention mold filter as this conventional-type filter, gap length G is set as 0.46λ ($G=0.46\lambda$).

[0047] The transmission characteristic was compared about each of the above-mentioned this invention mold filter and a conventional-type filter. The result is shown in drawing 4 and drawing 5. In addition, with this invention mold filter which measured the transmission characteristic of drawing 4 and drawing 5, the gap length G is set as 0.2λ ($G=0.2\lambda$). Moreover, the dotted line of this invention mold filter shows the transmission characteristic of a conventional-type filter, and a continuous line shows drawing 4 and drawing 5 by **, respectively. Furthermore, the axis of ordinate in drawing shows an insertion loss, and an axis of abscissa shows a frequency.

[0048] Drawing 4 measures the transmission characteristic of each above-mentioned filter simply. With this invention mold filter, it turns out that the tapering inclination of the transmission characteristic in a band is canceled, and surface smoothness can be improved as compared with a conventional-type filter, without changing any properties other than a passband so that clearly from drawing 4.

[0049] On the other hand, in each above-mentioned filter, in order to clarify the location and level of resonance mode, drawing 5 measures the wave of a transmission characteristic, after removing adjustment with an external circuit intentionally. If the level of resonance mode is seen so that clearly from the result of drawing 5, compared with a conventional-type filter, the peak level will rise with this invention mold filter. Therefore, it turns out that making it small has contributed gap length G on a flat disposition rather than the conventional configuration.

[0050] Next, the result evaluated quantitatively about the relation between the above-mentioned gap length G and the surface smoothness in a passband is shown below.

[0051] First, in the vertical joint mold filter of the above-mentioned basic configuration, when changing gap length G , it measured about change of the ripple deflection (deflection in a band) to gap length G it is changeless against the index of the above-mentioned surface smoothness. The result is shown in drawing 6. In addition, in drawing 6, it is a vertical joint mold filter in case the dummy electrode finger 33 does not have a square black dot (configuration of

drawing 1), and is a vertical joint mold filter in case the dummy electrode finger 33 has the black dot of a rhombus (configuration of drawing 3). Moreover, an axis of ordinate shows the deflection in a band (unit dB), and an axis of abscissa shows gap length G (lambda criteria). Furthermore, the die length of the dummy electrode finger 33 is about 2λ in this example.

[0052] If gap length G has become below 0.3λ so that clearly from the result of drawing 6 , it turns out that the value of ripple deflection is sufficiently small. It is very clear by filling $0.3\lambda \geq G$ with a vertical joint mold filter in case there is a dummy electrode especially that ripple deflection is fully falling.

[0053] Next, in the vertical joint mold filter of the above-mentioned basic configuration, when changing gap length G , it measured about change of the width of face (bandwidth) of the passband to gap length G . The result is shown in drawing 7 . In addition, drawing 7 is also a vertical joint mold filter in case the dummy electrode finger 33 does not have a square black dot (configuration of drawing 1), and it is a vertical joint mold filter in case the dummy electrode finger 33 has the black dot of a rhombus (configuration of drawing 3). Moreover, an axis of ordinate shows bandwidth (unit MHz), and an axis of abscissa shows gap length G (lambda criteria).

[0054] If gap length G has become below 0.3λ so that clearly from the result of drawing 7 , sufficiently good bandwidth can be obtained. On the other hand, it turns out that bandwidth will decrease rapidly if gap length G exceeds 0.3λ , and a superfluous narrow-band-ized phenomenon arises. If $0.3\lambda \geq G$ is not filled, it becomes impossible therefore, to obtain sufficient filter shape as a vertical joint mold filter.

[0055] Furthermore, if the value of ripple deflection is large, surface smoothness will worsen and a superfluous narrow-band-ized phenomenon will arise, so that clearly from the comparison of drawing 6 and drawing 7 , but if the above-mentioned gap length G is set below to 0.3λ , ripple deflection will be improved, the width of face of a passband will fully be secured, and it will become possible to prevent generating of a superfluous narrow-band-ized phenomenon.

[0056] Thus, at this invention, it is the revolution Y cut X propagation LiTaO₃. On a substrate, two or more IDT electrodes have been arranged at the single tier, and gap length G between the heads of an electrode finger and bus bars (electrode terminal) in an IDT electrode is set below to 0.3λ in the surface acoustic wave filter of the vertical joint resonator mold which has arranged the reflective structures, such as a reflector, so that this may be pinched further. Therefore, the surface smoothness in a passband can be raised and generating of a superfluous narrow-band-ized phenomenon can be prevented certainly.

[0057] [Gestalt 2 of operation] It will be as follows if the gestalt of operation of the 2nd of this invention is explained based on drawing 8 and drawing 9 . In addition, this invention is not limited to this. Moreover, the same number is appended to the member of explanation used with the gestalt 1 of said operation, and the member which has the same function for convenience, and the explanation is omitted.

[0058] The gestalt of this operation explains more concretely about the example applied to the communication device the vertical joint mold filter in the gestalt 1 of said operation, or surface acoustic wave equipment equipped with this.

[0059] As shown in drawing 8 , the communication device 100 in the gestalt of this operation Specifically as a receiver side (Rx side) which receives An antenna 101, the antenna common section / RFTop filter 102, amplifier 103, Rx interstage filter 104, a mixer 105, the 1stIF filter 106, a mixer 107, the 2ndIF filter 108, the 1st+2nd local synthesizer 111, TCXO (temperature compensated crystal oscillator (temperature-compensated crystal oscillator)) It has 112, the divider 113, and the local filter 114.

[0060] Moreover, as a transceiver side (Tx side) which transmits, the above-mentioned communication device 100 is equipped with the TxIF filter 121, a mixer 122, Tx interstage filter 123, amplifier 124, a coupler 125, an isolator 126, and APC (automatic power control) 127 (APC) while it shares the above-mentioned antenna 101, and the above-mentioned above-mentioned antenna common section / RFTop filter 102.

[0061] And surface acoustic wave equipment equipped with the vertical joint mold filter of the gestalt 1 of operation or this which was mentioned above can be suitably used for Rx interstage filter 104, the 1stIF filter 106, the above-mentioned TxIF filter 121, or above-mentioned Tx interstage filter 123.

[0062] Thus, the surface acoustic wave filter (vertical joint mold filter) of the gestalt 1 of said operation or surface acoustic wave equipment equipped with this is used for the above-mentioned communication device in the gestalt of this operation. Since the above-mentioned surface acoustic wave filter is equipped with the very good transmission characteristic, the communication device of the above-mentioned configuration can be attaining the miniaturization with the good transceiver function more than the miniaturization, especially the GHz band.

[0063] Moreover, the example which uses the above-mentioned vertical joint mold filter or surface acoustic wave equipment equipped with this for the filter for RF of RKE (Remote Keyless Entry System) as other examples of the gestalt of this operation can be given.

[0064] That is, as shown in drawing 9, although RKE200 in the gestalt of this operation is equipped with an antenna 201, the RxTop filter 202, amplifier 203, the mixer 204, the 1stIF filter 205, and the 1st local filter 206 grade, it can use suitably for the above-mentioned RxTop filter 202 especially surface acoustic wave equipment equipped with the vertical joint mold filter of the gestalt 1 of operation or this which was mentioned above.

[0065]

[Effect of the Invention] As mentioned above, it sets in the surface acoustic wave filter of a vertical joint resonator mold, and the surface acoustic wave filter concerning this invention is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. While using a substrate, when spacing of the head of the above-mentioned electrode finger which one electrode terminal has, and the electrode terminal of another side which counters this is set to gap length G and wavelength of the above-mentioned surface acoustic wave is set to λ , it is the configuration that the relation of $0.3\lambda \geq G$ is materialized.

[0066] If the wavelength λ of a surface acoustic wave is shorter than 0.3 times and the above-mentioned gap length G is carried out, since the non-exciting field equivalent to the free surface can be made small according to the above-mentioned configuration, it becomes possible to suppress generating of SSBW. Therefore, aggravation of the surface smoothness in a passband can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the effectiveness that the surface acoustic wave filter which has a high filter shape can be obtained is done so.

[0067] The surface acoustic wave filter concerning this invention is the configuration of having two or more dummy electrode fingers formed so that the above-mentioned electrode finger extended from the other party's electrode terminal may be countered, when the above-mentioned electrode terminal projects toward the above-mentioned opposite direction further in addition to the above-mentioned configuration.

[0068] According to the above-mentioned configuration, it becomes possible by forming a dummy electrode finger to suppress generating of Above SSBW further so that the above-mentioned electrode finger may be countered. Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the effectiveness that the surface acoustic wave filter which has a still higher filter shape can be obtained is done so.

[0069] The surface acoustic wave equipment concerning this invention is a configuration equipped with the surface acoustic wave filter of the above-mentioned configuration.

[0070] Moreover, the communication device concerning this invention is the configuration of using the surface acoustic wave filter of the above-mentioned configuration, or the surface acoustic wave equipment of the above-mentioned configuration.

[0071] According to each above-mentioned configuration, since it has the surface acoustic wave filter of high quality, the effectiveness that the function as surface acoustic wave equipment or a communication device can be raised further is done so.

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TECHNICAL FIELD

[Field of the Invention] This invention relates to a communication device at a surface acoustic wave filter and surface acoustic wave equipment equipped with this, and a list, and is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate especially. It is related with a surface acoustic wave filter, and the surface acoustic wave equipment and the communication device using this of the vertical joint resonator mold using a substrate.

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PRIOR ART

[Description of the Prior Art] A surface acoustic wave filter is a filter containing the surface acoustic element using the surface acoustic wave spread along a piezo-electric substrate front face, for example, is used for various applications prepared in a RF circuit, such as a surface acoustic wave filter, in mobile communications commercial scenes, such as a cellular phone.

[0003] Especially, since wavelength is short compared with an electromagnetic wave, the above-mentioned surface acoustic wave has the advantage of being easy to miniaturize surface acoustic wave equipment equipped with a surface acoustic wave filter itself. Therefore, in the field of communication devices, such as the above-mentioned cellular phone with which recent years more much more miniaturization and low back-ization are called for, the need of the above-mentioned surface acoustic wave filter or surface acoustic wave equipment is also very large.

[0004] Here, also in the above-mentioned surface acoustic wave filter, since especially the surface acoustic wave filter (it abbreviates to a vertical joint mold filter hereafter) of a vertical joint resonator mold can respond to low loss and a RF, its surface acoustic wave filter is in use.

[0005] As a concrete technique about such a vertical joint mold filter, the vertical joint dual mode surface acoustic wave filter currently indicated by JP,5-267990,A, for example is mentioned.

[0006] The vertical joint mold filter of the above-mentioned technique carries out contiguity arrangement of the three INTADIJITARU transducer electrodes (IDT electrode) along the propagation direction of a surface acoustic wave on a piezo-electric substrate, and has the configuration which arranges a reflector on the both sides further. And each IDT electrode limits spacing of the center to center of the electrode finger of the innermost part which counters mutually on the basis of the wavelength λ of a surface acoustic wave. Consequently, it is possible to be able to realize the fractional bandwidth which reaches to 4%, even if it is a RF field near 1GHz, and to also make loss low.

[0007] By the way, although there are various things according to the application of this filter as a property required of a vertical joint mold filter including the technique of the above-mentioned official report, the filter for RKE(Remote Keyless Entry System) RF requires the property (narrow-band property) used as a narrow band especially, for example so that it can respond to necessary pass band width. In the former, in order to realize the above-mentioned narrow-band property to the vertical joint mold filter of this application, the Xtal substrate which has a zero temperature coefficient has been used as a piezo-electric substrate.

[0008] However, since the above-mentioned Xtal substrate has a low dielectric constant, an electromechanical coupling coefficient is also small and the impedance of the filter itself becomes high, a matching circuit is needed separately to a vertical joint mold filter. So, with the above-mentioned configuration, the inconvenient point in respect of [, such as complication of a configuration or an increment in components mark,] manufacture had arisen. And since loss became large, with the above-mentioned configuration, inconvenience had produced the vertical joint mold filter obtained also in respect of quality.

[0009] Then, in order to realize the above-mentioned narrow-band property recently, it is the revolution Y cut X propagation LiTaO3 especially as a piezo-electric substrate. The substrate is used more often. This revolution Y cut X propagation LiTaO3 As compared with what used the Xtal substrate, low impedance-ization of the vertical joint mold filter using a substrate is attained, and it is possible to control the above-mentioned inconvenience.

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EFFECT OF THE INVENTION

[Effect of the Invention] As mentioned above, it sets in the surface acoustic wave filter of a vertical joint resonator mold, and the surface acoustic wave filter concerning this invention is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. While using a substrate, when spacing of the head of the above-mentioned electrode finger which one electrode terminal has, and the electrode terminal of another side which counters this is set to gap length G and wavelength of the above-mentioned surface acoustic wave is set to λ , it is the configuration that the relation of $0.3\lambda \geq G$ is materialized.

[0066] If the wavelength λ of a surface acoustic wave is shorter than 0.3 times and the above-mentioned gap length G is carried out, since the non-exciting field equivalent to the free surface can be made small according to the above-mentioned configuration, it becomes possible to suppress generating of SSBW. Therefore, aggravation of the surface smoothness in a passband can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the effectiveness that the surface acoustic wave filter which has a high filter shape can be obtained is done so.

[0067] The surface acoustic wave filter concerning this invention is the configuration of having two or more dummy electrode fingers formed so that the above-mentioned electrode finger extended from the other party's electrode terminal may be countered, when the above-mentioned electrode terminal projects toward the above-mentioned opposite direction further in addition to the above-mentioned configuration.

[0068] According to the above-mentioned configuration, it becomes possible by forming a dummy electrode finger to suppress generating of Above SSBW further so that the above-mentioned electrode finger may be countered. Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the effectiveness that the surface acoustic wave filter which has a still higher filter shape can be obtained is done so.

[0069] The surface acoustic wave equipment concerning this invention is a configuration equipped with the surface acoustic wave filter of the above-mentioned configuration.

[0070] Moreover, the communication device concerning this invention is the configuration of using the surface acoustic wave filter of the above-mentioned configuration, or the surface acoustic wave equipment of the above-mentioned configuration.

[0071] According to each above-mentioned configuration, since it has the surface acoustic wave filter of high quality, the effectiveness that the function as surface acoustic wave equipment or a communication device can be raised further is done so.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, it is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. If the vertical joint mold filter using a substrate tends to realize the above-mentioned narrow-band property, the trouble that surface smoothness worsens shortly will be produced.

[0011] As shown in drawing 10, with the conventional vertical joint mold filter, the wave of a passband tapers off and, specifically, it has become a configuration (drawing Nakaya mark). Therefore, the ripple deflection used as the index of the surface smoothness in a passband gets worse, and the trouble that the width of face of a passband becomes narrow beyond the need is produced. In addition, the phenomenon in which the width of face of a passband becomes narrow beyond the need is made into a superfluous narrow-band-ized phenomenon.

[0012] This invention is made in view of the above-mentioned trouble, and the object is in offering a surface acoustic wave filter, and the surface acoustic wave equipment and the communication device using this of the quality vertical joint resonator mold which has the good filter shape which raised the surface smoothness in a passband further.

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MEANS

[Means for Solving the Problem] this invention persons set in the surface acoustic wave filter of a vertical joint resonator mold, as a result of inquiring wholeheartedly, in order to cancel the above-mentioned trouble. As a piezo-electric substrate, it is the revolution Y cut X propagation LiTaO₃. While using a substrate If spacing of the electrode finger which constitutes an IDT electrode, and the bus bar (electrode terminal) which counters this electrode finger is specified in the predetermined range based on the wavelength λ of a surface acoustic wave The surface smoothness in a passband improves and it came to complete a header and this invention for a good filter shape being realized uniquely.

[0014] Namely, the surface acoustic wave filter concerning this invention In order to solve the above-mentioned technical problem, it has two or more electrode fingers extended toward the opposite direction from the electrode terminal and each electrode terminal of the couple which counters mutually. The INTADIJITARU transducer (IDT) electrode which forms the configuration where made these two or more electrode fingers cross, respectively, and each other were engaged In the surface acoustic wave filter of the vertical joint resonator mold which carries out contiguity arrangement along the propagation direction of a surface acoustic wave, and equips the both sides with two or more surface acoustic wave resonators which come to arrange the reflective structure further on a piezo-electric substrate It is the revolution Y cut X propagation LiTaO₃ as the above-mentioned piezo-electric substrate. While using a substrate When spacing of the head of the above-mentioned electrode finger which one electrode terminal has, and the electrode terminal of another side which counters this is set to gap length G and wavelength of the above-mentioned surface acoustic wave is set to λ , it is characterized by materializing the relation of $0.3\lambda \geq G$.

[0015] As a result of this invention persons' inquiring uniquely, it was considered to be the cause that the level of resonance mode decreased aggravation of the above-mentioned surface smoothness and generating of the superfluous narrow-band-ized phenomenon accompanying this under the effect of SSBW (Surface Skimming Bulk Wave) generated in the gap field between the head of the above-mentioned electrode finger and an electrode terminal (bus bar). It is known that this SSBW will be strongly emitted in the free surface. Therefore, if the non-exciting field which is equivalent to the free surface in an IDT electrode is made small, it will become possible to suppress generating of SSBW.

[0016] Then, according to the above-mentioned configuration, the wavelength λ of a surface acoustic wave is shorter than 0.3 times, and gap length G which is spacing of the head of the above-mentioned electrode finger and an electrode terminal is carried out. Therefore, since the non-exciting field (gap field) equivalent to the above-mentioned free surface can be made small, it becomes possible to suppress generating of Above SSBW. Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous narrow-band-ized phenomenon can be prevented effectively. Consequently, the surface acoustic wave filter which has a high filter shape can be obtained.

[0017] In addition to the above-mentioned configuration, the surface acoustic wave filter concerning this invention is characterized by having two or more dummy electrode fingers formed so that the above-mentioned electrode finger extended from the other party's electrode terminal when the above-mentioned electrode terminal projects toward the above-mentioned opposite direction further may be countered.

[0018] According to the above-mentioned configuration, it becomes possible by forming a dummy electrode finger to suppress generating of Above SSBW further so that the above-mentioned electrode finger may be countered. Therefore, aggravation of the above-mentioned surface smoothness can be avoided and generating of a superfluous

narrow-band-ized phenomenon can be prevented effectively. Consequently, the surface acoustic wave filter which has a still higher filter shape can be obtained.

[0019] The surface acoustic wave equipment concerning this invention is characterized by having the surface acoustic wave filter of the above-mentioned configuration.

[0020] Moreover, the communication device concerning this invention is characterized by using the surface acoustic wave filter of the above-mentioned configuration, or the surface acoustic wave equipment of the above-mentioned configuration.

[0021] According to each above-mentioned configuration, since it has the surface acoustic wave filter of high quality, the function as surface acoustic wave equipment or a communication device can be raised further.

[0022]

[Embodiment of the Invention] [Gestalt 1 of operation] It will be as follows if the gestalt of operation of the 1st of this invention is explained based on drawing 1 thru/or drawing 7. In addition, this invention is not limited to this.

[0023] The surface acoustic wave filter concerning this invention is the revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. On a substrate Have the resonator which has two or more INTADIJITARU transducer (IDT) electrodes and the reflective structure arranged so that this may be pinched. When wavelength of a surface acoustic wave is set to λ , gap length G between the head of two or more electrode fingers which are the surface acoustic wave filters (vertical joint mold filter) of a vertical joint resonator mold, and the above-mentioned IDT electrode has, and the electrode terminal (bus bar) which counters it It sets up so that the relation of $0.3\lambda \geq G$ may be materialized.

[0024] Moreover, the surface acoustic wave equipment concerning this invention is equipped with the surface acoustic wave filter of the above-mentioned configuration.

[0025] Specifically, for the vertical joint mold filter [in / as shown in drawing 2 / the gestalt of this operation] 1, the surface acoustic wave resonator 5 (it only considers as a resonator hereafter) which becomes two or more IDT electrode 3 -- from the reflector (reflector) 4-4 of a couple is LiTaO₃. It has composition formed on [two] the substrate 2. In addition, a reflective end face may be used instead of a reflector. Namely, the reflective structure of a wide sense should just be used.

[0026] Contiguity arrangement of three IDT electrode 3a, 3b, and the 3c is carried out, and the above-mentioned resonator 5 has the composition that the reflector 4-4 of a couple is arranged to these ends. The direction where three IDT electrode 3a, 3b, and 3c are arranged is a direction which met in the propagation direction of the surface acoustic wave in the above-mentioned vertical joint mold filter 1. Moreover, since it is arranged so that above-mentioned IDT electrode 3a, 3b, and 3c may be pinched, the reflector 4-4 will be arranged along the propagation direction of a surface acoustic wave like the orientation of IDT electrode 3a, 3b, and 3c.

[0027] With the gestalt of this operation, among three above-mentioned IDT electrode 3a, 3b, and 3c, the end of IDT electrode 3a and 3c is grounded, and the signal terminal 7 is formed in IDT electrode 3b.

[0028] In the above-mentioned vertical joint mold filter 1, the direction where the resonator 5-5 is arranged is a direction (lengthwise direction) which intersects perpendicularly in the propagation direction of the above-mentioned surface acoustic wave. And cascade connection of between resonators 5-5 is done by the connection 6 between each IDT electrode 3a, 3b, and 3c. Therefore, the vertical joint mold filter 1 of the above-mentioned configuration has the so-called two-step composition. In addition, the joint capacity formed with the ctenidium-like electrode so that the above-mentioned connection 6 could take adjustment of interstage may have composition connected so that it may become parallel electrically with the above-mentioned IDT electrode 3, and it is not limited especially.

[0029] In addition, as a configuration of the above-mentioned vertical joint mold filter 1, it is not limited to the above-mentioned two-step configuration. For example, you may be what formed one resonator 5 and made the connection number of stages one step, i.e., the thing of a single stage configuration, and may be what prepared three or more resonator 5 --, i.e., the thing of three or more steps of multistage configurations. Moreover, between each resonator 5-5, the connection method of interstage is not limited to the above-mentioned approach, either, and may be changed into other connection methods.

[0030] In drawing 2, although each IDT electrode 3a, 3b, and 3c are illustrated typically, it has the composition of having two or more electrode finger (excitation electrode finger) 32 -- extended toward the bus bar (electrode terminal) 31-31 and each bus bar 31 of the couple which counters mutually as it is shown in drawing 1, when a configuration is illustrated more concretely to the opposite direction of these IDT(s) electrode 3 --. Two or more above-mentioned

electrode finger 32 -- crosses, respectively, and has become the configuration which was engaged mutually.

[0031] The logarithm of one pair, then the electrode finger 32-32 which constitutes the IDT electrode 3 is suitably set up according to the demand characteristics of the vertical joint mold filter 1 in the combination of the electrode finger 32-32 per piece extended, respectively from each bus bar 31-31 which counters. Similarly, the width of face (decussation width of face) which each electrode finger 32 extended, respectively intersects is suitably set up according to demand characteristics from the bus bar 31-31 which counters.

[0032] Furthermore, by this invention, as shown in drawing 1, when spacing of the head of the above-mentioned electrode finger 32 and the bus bar 31 which counters this is set to gap length G and this gap length G sets wavelength of a surface acoustic wave to λ , it is specified that the relation of $0.3\lambda \geq G$ is materialized.

[0033] It is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. With the vertical joint mold filter using a substrate, if it is going to realize a narrow-band property, the superfluous narrow-band-ized phenomenon which surface smoothness worsened, therefore was mentioned above will arise. This superfluous narrow-band-ized phenomenon is a gap field between the head of the above-mentioned electrode finger, and a bus bar, and is considered for SSBW (Surface Skimming Bulk Wave) to occur. That is, SSBW is the effect generated in the above-mentioned gap field, and it is for the level of resonance mode to decline.

[0034] It is known that Above SSBW will be strongly emitted in the free surface. Then, in an IDT electrode, it is making small the non-exciting field equivalent to the above-mentioned free surface, and it becomes possible to suppress generating of Above SSBW.

[0035] Here, as shown in drawing 1, the gap field 30 between the head of the electrode finger 32 in the IDT electrode 3 and the bus bar 31 which counters it is excitation with the free surface which has not contributed. So, if the above-mentioned gap length G is shortened, since the gap field 30 will become narrow, a non-exciting field can be made small. Consequently, the surface smoothness in a passband can be improved and it becomes possible to prevent a superfluous narrow-band-ized phenomenon.

[0036] When the correlation with the above-mentioned gap length G , the deflection in a band (ripple deflection), and the width of face (bandwidth) of a passband was acquired, wavelength of a surface acoustic wave was set to λ and the above-mentioned gap length G was actually specified below to 0.3λ so that clearly from the example mentioned later, it was found out that the deflection in a band and bandwidth are improved. The above-mentioned ripple deflection is the index of surface smoothness, and it becomes good [surface smoothness], so that this value is small. In this invention, when it prescribed that gap length G became $0.3\lambda \geq G$, it turned out that ripple deflection is improved and bandwidth also becomes large.

[0037] In addition, although, as for gap length G , only 0.3λ is specified as an upper limit and the minimum is not specified, the above-mentioned gap length G is that which points out spacing of the head of the electrode finger 32, and a bus bar 31, and always exceeds 0 until it gets tired ($G > 0$), and this is because it is not necessary to limit a minimum.

[0038] That is, in this invention, the lower limit of gap length G will be equivalent to the threshold value on the process at the time of forming the above-mentioned IDT electrode 3 to the upper limit of gap length G being 0.3λ . For example, as an approach of forming the IDT electrode 3, although the wet etching method can generally be used, it is also possible to use the dry etching method. At this time, the threshold value of gap length G obtained by the dry etching method becomes smaller than the threshold value of gap length G obtained by the wet etching method. Therefore, the minimum of gap length G serves as threshold value of the process which forms the IDT electrode 3.

[0039] In this invention, further, as shown in drawing 3, the IDT electrode 3 has projected toward the above-mentioned opposite direction, and may have two or more dummy electrode finger 33 -- formed so that the above-mentioned electrode finger 32 extended from the other party's bus bar 31 may be countered. That is, the dummy electrode 33 will be formed so that it may project from a bus bar 31 to the gap field 30 which is a non-exciting field.

[0040] Thus, if the dummy electrode finger 33 which counters the above-mentioned electrode finger 32 is formed, it is possible to be able to avoid aggravation of the above-mentioned surface smoothness much more certainly, and to prevent generating of a superfluous narrow-band-ized phenomenon more effectively so that clearly from the example mentioned later.

[0041] In addition, gap length G in case there is a dummy electrode finger 33 shall point out spacing from the head of the electrode finger 32 to the head of the dummy electrode finger 33 which counters it, as shown in drawing 3. So, the die length of the dummy electrode finger 33 is a design matter chosen suitably, and is not especially limited by the size of above-mentioned gap length G and the IDT electrode 3 etc.

[0042] At this invention, it is the above-mentioned revolution Y cut X propagation LiTaO₃ as a piezo-electric substrate. A substrate 2 is used. This revolution Y cut X propagation LiTaO₃ As a substrate 2, it is not especially specifically limited. At the example mentioned later, it is the revolution Y cut X propagation LiTaO₃. Although the thing of 36-degree revolution Y cut X propagation is used, even if cut angles other than this are used for the cut angle of a substrate 2, since the difference in physical properties does not participate in radiation of SSBW, it can acquire the same effectiveness.

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EXAMPLE

[Example] A convention of the above-mentioned gap length G in the gestalt of this operation is more concretely explained based on the following examples. In addition, this example is an example for specifying the above-mentioned gap length G , and this invention is not limited to this example.

[0044] The vertical joint mold filter 1 (refer to drawing 2) of the two-step configuration mentioned above is mentioned as an example, and this example explains it. The fundamental configuration of the vertical joint mold filter 1 used by this example is as follows.

[0045] That is, center frequency used as the center of the passband in the vertical joint mold filter 1 was first set to 298MHz. Moreover, as a piezo-electric substrate, it is the 36-degree revolution Y cut X propagation LiTaO₃. The substrate 2 was used. Electrode layer thickness was set to 400nm, using an aluminum-Cu alloy as an electrode material. As for each concrete configuration of the above-mentioned reflector 4, the number set wavelength to 13.82 micrometers by 41. Moreover, the logarithm of the electrode finger 32-32 in three IDT electrode 3a, 3b, and 3c shown in drawing 2 formed the concrete configuration of the above-mentioned IDT electrode 3 so that it might become 17 pairs, 22 pairs, and 17 pairs, respectively.

[0046] next, with the vertical joint mold filter (this invention mold filter) concerning this invention used by this example, when wavelength of a surface acoustic wave is set to λ , it becomes below 0.3λ about gap length G ($0.3\lambda \geq G$) -- it has set up small like. Furthermore, in this example, the conventional vertical joint mold filter (conventional-type filter) which does not set up gap length G small is also used as usual for the comparison. Although the fundamental configuration is the same as this invention mold filter as this conventional-type filter, gap length G is set as 0.46λ ($G=0.46\lambda$).

[0047] The transmission characteristic was compared about each of the above-mentioned this invention mold filter and a conventional-type filter. The result is shown in drawing 4 and drawing 5. In addition, with this invention mold filter which measured the transmission characteristic of drawing 4 and drawing 5, the gap length G is set as 0.2λ ($G=0.2\lambda$). Moreover, the dotted line of this invention mold filter shows the transmission characteristic of a conventional-type filter, and a continuous line shows drawing 4 and drawing 5 by **, respectively. Furthermore, the axis of ordinate in drawing shows an insertion loss, and an axis of abscissa shows a frequency.

[0048] Drawing 4 measures the transmission characteristic of each above-mentioned filter simply. With this invention mold filter, it turns out that the tapering inclination of the transmission characteristic in a band is canceled, and surface smoothness can be improved as compared with a conventional-type filter, without changing any properties other than a passband so that clearly from drawing 4.

[0049] On the other hand, in each above-mentioned filter, in order to clarify the location and level of resonance mode, drawing 5 measures the wave of a transmission characteristic, after removing adjustment with an external circuit intentionally. If the level of resonance mode is seen so that clearly from the result of drawing 5, compared with a conventional-type filter, the peak level will rise with this invention mold filter. Therefore, it turns out that making it small has contributed gap length G on a flat disposition rather than the conventional configuration.

[0050] Next, the result evaluated quantitatively about the relation between the above-mentioned gap length G and the surface smoothness in a passband is shown below.

[0051] First, in the vertical joint mold filter of the above-mentioned basic configuration, when changing gap length G , it measured about change of the ripple deflection (deflection in a band) to gap length G it is changeless against the index of the above-mentioned surface smoothness. The result is shown in drawing 6. In addition, in drawing 6, it is a

vertical joint mold filter in case the dummy electrode finger 33 does not have a square black dot (configuration of drawing 1), and is a vertical joint mold filter in case the dummy electrode finger 33 has the black dot of a rhombus (configuration of drawing 3). Moreover, an axis of ordinate shows the deflection in a band (unit dB), and an axis of abscissa shows gap length G (λ criteria). Furthermore, the die length of the dummy electrode finger 33 is about 2λ in this example.

[0052] If gap length G has become below 0.3λ so that clearly from the result of drawing 6 , it turns out that the value of ripple deflection is sufficiently small. It is very clear by filling $0.3\lambda \geq G$ with a vertical joint mold filter in case there is a dummy electrode especially that ripple deflection is fully falling.

[0053] Next, in the vertical joint mold filter of the above-mentioned basic configuration, when changing gap length G , it measured about change of the width of face (bandwidth) of the passband to gap length G . The result is shown in drawing 7 . In addition, drawing 7 is also a vertical joint mold filter in case the dummy electrode finger 33 does not have a square black dot (configuration of drawing 1), and it is a vertical joint mold filter in case the dummy electrode finger 33 has the black dot of a rhombus (configuration of drawing 3). Moreover, an axis of ordinate shows bandwidth (unit MHz), and an axis of abscissa shows gap length G (λ criteria).

[0054] If gap length G has become below 0.3λ so that clearly from the result of drawing 7 , sufficiently good bandwidth can be obtained. On the other hand, it turns out that bandwidth will decrease rapidly if gap length G exceeds 0.3λ , and a superfluous narrow-band-ized phenomenon arises. If $0.3\lambda \geq G$ is not filled, it becomes impossible therefore, to obtain sufficient filter shape as a vertical joint mold filter.

[0055] Furthermore, if the value of ripple deflection is large, surface smoothness will worsen and a superfluous narrow-band-ized phenomenon will arise, so that clearly from the comparison of drawing 6 and drawing 7 , but if the above-mentioned gap length G is set below to 0.3λ , ripple deflection will be improved, the width of face of a passband will fully be secured, and it will become possible to prevent generating of a superfluous narrow-band-ized phenomenon.

[0056] Thus, at this invention, it is the revolution Y cut X propagation LiTaO₃. On a substrate, two or more IDT electrodes have been arranged at the single tier, and gap length G between the heads of an electrode finger and bus bars (electrode terminal) in an IDT electrode is set below to 0.3λ in the surface acoustic wave filter of the vertical joint resonator mold which has arranged the reflective structures, such as a reflector, so that this may be pinched further. Therefore, the surface smoothness in a passband can be raised and generating of a superfluous narrow-band-ized phenomenon can be prevented certainly.

[0057] [Gestalt 2 of operation] It will be as follows if the gestalt of operation of the 2nd of this invention is explained based on drawing 8 and drawing 9 . In addition, this invention is not limited to this. Moreover, the same number is appended to the member of explanation used with the gestalt 1 of said operation, and the member which has the same function for convenience, and the explanation is omitted.

[0058] The gestalt of this operation explains more concretely about the example applied to the communication device the vertical joint mold filter in the gestalt 1 of said operation, or surface acoustic wave equipment equipped with this.

[0059] As shown in drawing 8 , the communication device 100 in the gestalt of this operation Specifically as a receiver side (Rx side) which receives An antenna 101, the antenna common section / RFTop filter 102, amplifier 103, Rx interstage filter 104, a mixer 105, the 1stIF filter 106, a mixer 107, the 2ndIF filter 108, the 1st+2nd local synthesizer 111, TCXO (temperature compensated crystal oscillator (temperature-compensated crystal oscillator)) It has 112, the divider 113, and the local filter 114.

[0060] Moreover, as a transceiver side (Tx side) which transmits, the above-mentioned communication device 100 is equipped with the TxIF filter 121, a mixer 122, Tx interstage filter 123, amplifier 124, a coupler 125, an isolator 126, and APC (automatic power control) 127 (APC) while it shares the above-mentioned antenna 101, and the above-mentioned above-mentioned antenna common section / RFTop filter 102.

[0061] And surface acoustic wave equipment equipped with the vertical joint mold filter of the gestalt 1 of operation or this which was mentioned above can be suitably used for Rx interstage filter 104, the 1stIF filter 106, the above-mentioned TxIF filter 121, or above-mentioned Tx interstage filter 123.

[0062] Thus, the surface acoustic wave filter (vertical joint mold filter) of the gestalt 1 of said operation or surface acoustic wave equipment equipped with this is used for the above-mentioned communication device in the gestalt of this operation. Since the above-mentioned surface acoustic wave filter is equipped with the very good transmission characteristic, the communication device of the above-mentioned configuration can be attaining the miniaturization

with the good transceiver function more than the miniaturization, especially the GHz band.

[0063] Moreover, the example which uses the above-mentioned vertical joint mold filter or surface acoustic wave equipment equipped with this for the filter for RF of RKE (Remote Keyless Entry System) as other examples of the gestalt of this operation can be given.

[0064] That is, as shown in drawing 9 , although RKE200 in the gestalt of this operation is equipped with an antenna 201, the RxTop filter 202, amplifier 203, the mixer 204, the 1stIF filter 205, and the 1st local filter 206 grade, it can use suitably for the above-mentioned RxTop filter 202 especially surface acoustic wave equipment equipped with the vertical joint mold filter of the gestalt 1 of operation or this which was mentioned above.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing the outline configuration of the IDT electrode contained in the surface acoustic wave filter concerning this invention.

[Drawing 2] It is the top view showing an example containing the IDT electrode shown in drawing 1 of the outline configuration of the surface acoustic wave filter concerning this invention.

[Drawing 3] It is the outline top view showing other configurations of the IDT electrode shown in drawing 1.

[Drawing 4] It is the graph which compares the transmission characteristic in the surface acoustic wave filter concerning this invention with the transmission characteristic in the conventional surface acoustic wave filter.

[Drawing 5] It is the graph which compares the transmission characteristic in the surface acoustic wave filter concerning this invention with the transmission characteristic in the conventional surface acoustic wave filter, and is the graph which shows the transmission characteristic acquired where adjustment is removed.

[Drawing 6] In the surface acoustic wave filter concerning this invention, it is the graph which shows the relation of the deflection in a band to gap length G.

[Drawing 7] In the surface acoustic wave filter concerning this invention, it is the graph which shows the relation of the width of face of the passband to gap length G.

[Drawing 8] It is the important section block diagram of the communication device concerning this invention.

[Drawing 9] It is the important section block diagram of RKE as other examples of the communication device concerning this invention.

[Drawing 10] It is the graph which shows the transmission characteristic of the vertical joint mold filter of the conventional configuration.

[Description of Notations]

1 Surface Acoustic Wave Filter of Vertical Joint Resonator Mold (Vertical Coupling Filter)

2 Revolution Y Cut X Propagation LiTaO₃ Substrate

3 INTADIJITARU Transducer Electrode (IDT Electrode)

4 Reflector

31 Bus Bar (Electrode Terminal)

32 Electrode Finger

33 Dummy Electrode Finger

G Gap length

100 Communication Device

200 RKE (Communication Device)

[Translation done.]

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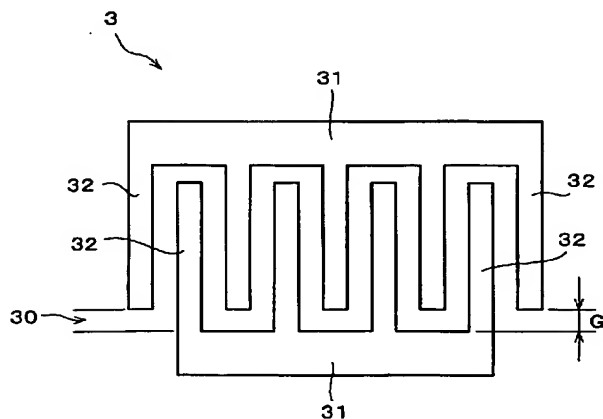
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(54) 【発明の名称】 弾性表面波フィルタ、弾性表面波装置および通信装置

(57) 【要約】

【課題】 通過帯域内の平坦度をより一層向上させた良好なフィルタ特性を有する、高品質な縦結合共振器型の弾性表面波フィルタを提供する。

【解決手段】 本発明では、上記圧電基板として回転YカットX伝搬LiTaO₃基板を用いるとともに、弾性表面波共振子を構成するIDT電極3におけるギャップ長Gを、弾性表面波の波長λの0.3倍以下に規定する(0.3λ ≥ G)。上記ギャップ長Gは、IDT電極3を構成する一対のバスバー31と、このバスバー31から対向方向に向かって延長される複数の電極指32…との間隔である。



【特許請求の範囲】

【請求項 1】互いに対向する一対の電極端子と、各電極端子から対向方向に向かって延長される複数の電極指とを有し、該複数の電極指をそれぞれ交叉させて互いに噛み合わせた形状を形成するインターデジタルトランス

デューサ電極を、圧電基板上に、複数個、弾性表面波の伝搬方向に沿って隣接配置し、さらにその両側に、反射構造体を配置してなる弾性表面波共振子を備える縦結合共振子型の弾性表面波フィルタにおいて、

上記圧電基板として回転 Y カット X 伝搬 LiTaO_3 基板を用いるとともに、一方の電極端子が有する上記電極指の先端と、これに対向する他方の電極端子との間隔をギャップ長 G とし、上記弾性表面波の波長を λ とした場合に、 $0.3\lambda \leq G$ の関係が成立することを特徴とする弾性表面波フィルタ。

【請求項 2】上記電極端子は、さらに、上記対向方向に向かって突き出すことにより、相手方の電極端子から延長される上記電極指に対向するように形成される複数のダミー電極指を有することを特徴とする請求項 1 記載の弾性表面波フィルタ。

【請求項 3】請求項 1 または 2 記載の弾性表面波フィルタを備えることを特徴とする弾性表面波装置。

【請求項 4】請求項 1 または 2 記載の弾性表面波フィルタ、または請求項 3 記載の弾性表面波装置を用いることを特徴とする通信装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、弾性表面波フィルタ、およびこれを備える弾性表面波装置、並びに通信装置に関するものであり、特に、圧電基板として、回転 Y カット X 伝搬 LiTaO_3 基板を用いた縦結合共振子型の弾性表面波フィルタと、これを用いる弾性表面波装置および通信装置とに関するものである。

【0002】

【従来の技術】弾性表面波フィルタは、圧電基板表面に沿って伝搬する弾性表面波を利用した弾性表面波素子を含むフィルタであり、たとえば携帯電話などの移動体通信市場においては、高周波回路に設けられる弾性表面波フィルタなど、様々な用途に用いられている。

【0003】特に、上記弾性表面波は電磁波に比べて波長が短いため、弾性表面波フィルタを備える弾性表面波装置そのものを小型化し易いなどの利点がある。そのため、近年、より一層の小型化や低背化が求められている上記携帯電話などの通信装置の分野では、上記弾性表面波フィルタや弾性表面波装置の需要も非常に大きくなっている。

【0004】ここで、上記弾性表面波フィルタの中でも、特に、縦結合共振子型の弾性表面波フィルタ（以下、縦結合型フィルタと略す）は、低損失かつ高周波に対応することができるため、弾性表面波フィルタの主流

となっている。

【0005】このような縦結合型フィルタに関する具体的な技術としては、たとえば特開平 5-267990 号公報に開示されている縦結合二重モード弾性表面波フィルタが挙げられる。

【0006】上記技術の縦結合型フィルタは、3 個のインターデジタルトランスデューサ電極（IDT 電極）を、圧電基板上に、弾性表面波の伝搬方向に沿って隣接配置し、さらにその両側に反射器を配置する構成を有している。そして、各 IDT 電極が互いに対向する最も内側の電極指の中心間の間隔を、弾性表面波の波長 λ を基準にして限定している。その結果、1 GHz に近い高周波領域であっても 4 % に及ぶ帯域を実現でき、かつ、損失も低くすることが可能となっている。

【0007】ところで、上記公報の技術を含む、縦結合型フィルタに要求される特性としては、該フィルタの用途に応じて様々なものがあるが、中でも、たとえば RKE（Remote Keyless Entry System）RF 用フィルタでは、所要の通過帯域幅に対応し得るように、狭い帯域となる特性（狭帯域特性）が要求される。従来では、この用途の縦結合型フィルタに対しては、上記狭帯域特性を実現するために、圧電基板として、零温度係数を有する水晶基板が用いられてきた。

【0008】しかしながら、上記水晶基板は誘電率が低く、電気機械結合係数も小さいことから、フィルタそのもののインピーダンスが高くなるため、縦結合型フィルタに対して、別途、整合回路が必要となる。それゆえ、上記構成では、構成の複雑化や部品点数の増加といった製造面での不都合な点が生じていた。しかも、得られる縦結合型フィルタは、損失が大きくなってしまったため、上記構成では、品質の面でも不都合が生じていた。

【0009】そこで最近では、上記狭帯域特性を実現するために、圧電基板として、特に回転 Y カット X 伝搬 LiTaO_3 基板を用いることが多くなっている。この回転 Y カット X 伝搬 LiTaO_3 基板を用いた縦結合型フィルタは、水晶基板を用いたものと比較して、低インピーダンス化が可能となっており、上記不都合を抑制することが可能となっている。

【0010】

【発明が解決しようとする課題】ところが、圧電基板として上記回転 Y カット X 伝搬 LiTaO_3 基板を用いた縦結合型フィルタで上記狭帯域特性を実現しようとすると、今度は、平坦性が悪くなるという問題点を生ずる。

【0011】具体的には、図 10 に示すように、従来の縦結合型フィルタでは、通過帯域の波形が先細り形状となっている（図中矢印）。そのため、通過帯域内における平坦性の指標となるリップル偏差が悪化し、通過帯域の幅が必要以上に狭くなるという問題点を生ずる。なお、通過帯域の幅が必要以上に狭くなる現象を、過剰狭帯域化現象とする。

【0012】本発明は、上記問題点を鑑みてなされたものであって、その目的は、通過帯域内の平坦性をより一層向上させた良好なフィルタ特性を有する、高品質な縦結合共振子型の弾性表面波フィルタと、これを用いた弾性表面波装置および通信装置を提供することにある。

【0013】

【課題を解決するための手段】本発明者らは、上記問題点を解消するために鋭意検討した結果、縦結合共振子型の弾性表面波フィルタにおいては、圧電基板として、回転YカットX伝搬LiTaO₃基板を用いるとともに、IDT電極を構成する電極指と、この電極指に対向するバスバー（電極端子）との間隔を、弾性表面波の波長λに基づいて所定範囲に規定すると、通過帯域内における平坦性が向上し、良好なフィルタ特性が実現されることを独自に見出し、本発明を完成するに至った。

【0014】すなわち、本発明にかかる弾性表面波フィルタは、上記の課題を解決するために、互いに対向する一対の電極端子と、各電極端子から対向方向に向かって延長される複数の電極指とを有し、該複数の電極指をそれぞれ交叉させて互いに噛み合わせた形状を形成するインターディジタルトランスデューサ（IDT）電極を、圧電基板上に、複数個、弾性表面波の伝搬方向に沿って隣接配置し、さらにその両側に、反射構造体を配置してなる弾性表面波共振子を備える縦結合共振子型の弾性表面波フィルタにおいて、上記圧電基板として回転YカットX伝搬LiTaO₃基板を用いるとともに、一方の電極端子が有する上記電極指の先端と、これに対向する他方の電極端子との間隔をギャップ長Gとし、上記弾性表面波の波長をλとした場合に、 $0.3\lambda \leq G$ の関係が成立することを特徴としている。

【0015】本発明者らが独自に検討した結果、上記平坦性の悪化と、これに伴う過剰狭帯域化現象の発生とは、上記電極指の先端と電極端子（バスバー）との間のギャップ領域で発生するSSBW（Surface Skimming Bulk Wave）の影響により、共振モードのレベルが減衰することが原因ではないかと考えられた。このSSBWは、自由表面において強く放射されることが知られている。そのため、IDT電極において自由表面に相当する非励振領域を小さくすれば、SSBWの発生を抑えることが可能となる。

【0016】そこで、上記構成によれば、上記電極指の先端と電極端子との間隔であるギャップ長Gを、弾性表面波の波長λの0.3倍よりも短くしている。そのため、上記自由表面に相当する非励振領域（ギャップ領域）を小さくすることができるので、上記SSBWの発生を抑えることが可能となる。そのため、上記平坦性の悪化を回避し、過剰狭帯域化現象の発生を効果的に防止することができる。その結果、高いフィルタ特性を有する弾性表面波フィルタを得ることができる。

【0017】本発明にかかる弾性表面波フィルタは、上

記構成に加えて、上記電極端子が、さらに、上記対向方向に向かって突き出すことにより、相手方の電極端子から延長される上記電極指に対向するように形成される複数のダミー電極指を有することを特徴としている。

【0018】上記構成によれば、上記電極指に対向するように、ダミー電極指を設けることによって、上記SSBWの発生をより一層抑えることが可能となる。そのため、上記平坦性の悪化を回避し、過剰狭帯域化現象の発生を効果的に防止することができる。その結果、より一層高いフィルタ特性を有する弾性表面波フィルタを得ることができる。

【0019】本発明にかかる弾性表面波装置は、上記構成の弾性表面波フィルタを備えることを特徴としている。

【0020】また、本発明にかかる通信装置は、上記構成の弾性表面波フィルタ、または上記構成の弾性表面波装置を用いることを特徴としている。

【0021】上記各構成によれば、高品質の弾性表面波フィルタを備えているため、弾性表面波装置または通信装置としての機能をより一層向上させることができる。

【0022】

【発明の実施の形態】〔実施の形態1〕本発明の第1の実施の形態について図1ないし図7に基づいて説明すれば、以下の通りである。なお、本発明はこれに限定されるものではない。

【0023】本発明にかかる弾性表面波フィルタは、圧電基板としての回転YカットX伝搬LiTaO₃基板上に、複数のインターディジタルトランスデューサ（IDT）電極、およびこれを挟持するように配置される反射構造体を有する共振子を備える、縦結合共振子型の弾性表面波フィルタ（縦結合型フィルタ）であり、上記IDT電極が有する複数の電極指の先端と、これに対向する電極端子（バスバー）との間のギャップ長Gを、弾性表面波の波長をλとしたときに、 $0.3\lambda \leq G$ の関係が成立するように設定するものである。

【0024】また、本発明にかかる弾性表面波装置は、上記構成の弾性表面波フィルタを備えるものである。

【0025】具体的には、たとえば、図2に示すように、本実施の形態における縦結合型フィルタ1は、複数のIDT電極3…と、一対のリフレクタ（反射器）4・4とからなる弾性表面波共振子5（以下、単に共振子とする）が、LiTaO₃基板2上に二つ形成された構成となっている。なお、リフレクタの代わりに、反射端面を用いても構わない。すなわち広義の反射構造体を用いられればよい。

【0026】上記共振子5は、3個のIDT電極3a・3b・3cが隣接配置されており、この両端に一対のリフレクタ4・4が配置されている構成となっている。3個のIDT電極3a・3b・3cが配置されている方向は、上記縦結合型フィルタ1における弾性表面波の伝搬

方向に沿った方向である。また、リフレクタ4・4は、上記IDT電極3a・3b・3cを挟持するように配置されているため、IDT電極3a・3b・3cの配置方向と同様、弾性表面波の伝搬方向に沿って配置されていることになる。

【0027】本実施の形態では、上記3個のIDT電極3a・3b・3cのうち、IDT電極3a・3cの一端は接地されており、IDT電極3bには信号端子7が設けられている。

【0028】上記縦結合型フィルタ1において、共振子5・5が配置されている方向は、上記弾性表面波の伝搬方向に直交する方向（縦方向）である。そして、共振子5・5の間は、それぞれのIDT電極3a・3b・3cの間で、接続部6により縦続接続されている。そのため、上記構成の縦結合型フィルタ1は、いわゆる2段構成となっている。なお、上記接続部6は、段間の整合がとれるように、櫛歯状電極で形成された結合容量が、上記IDT電極3と電気的に並列となるように接続される構成となってもよく、特に限定されるものではない。

【0029】なお、上記縦結合型フィルタ1の構成としては、上記2段構成に限定されるものではない。たとえば、共振子5を一つのみ設けて接続段数を1段としたもの、すなわち単段構成のものであってもよく、共振子5…を3個以上設けたもの、すなわち3段以上の多段構成のものであってもよい。また、各共振子5・5の間、すなわち段間の接続方法も、上記方法に限定されるものではなく、他の接続方法に変えてもよい。

【0030】図2では、個々のIDT電極3a・3b・3cを模式的に図示しているが、これらIDT電極3…の構成をより具体的に図示すると、図1に示すように、互いに対向する一対のバスバー（電極端子）31・31と、各バスバー31から対向方向に向かって延長される複数の電極指（励振電極指）32…とを有する構成となっている。上記複数の電極指32…は、それぞれ交叉されて、互いに噛み合わせられたような形状となっている。

【0031】対向する各バスバー31・31からそれぞれ延長された1個ずつの電極指32・32の組み合わせを1対とすれば、IDT電極3を構成する電極指32・32の対数は、縦結合型フィルタ1の要求特性に応じて適宜設定される。同じく、対向するバスバー31・31からそれぞれ延長された各電極指32が交叉する幅（交叉幅）も、要求特性に応じて適宜設定される。

【0032】さらに、本発明では、図1に示すように、上記電極指32の先端と、これに対向するバスバー31との間隔をギャップ長Gとしており、このギャップ長Gが、弾性表面波の波長を λ とした場合に、 $0.3\lambda \leq G$ の関係が成立するように規定されている。

【0033】圧電基板として上記回転YカットX伝搬L

iTaO₃基板を用いた縦結合型フィルタでは、狭帯域特性を実現しようとする、平坦性が悪くなり、そのために前述した過剰狭帯域化現象が生じる。この過剰狭帯域化現象は、上記電極指の先端とバスバーの間のギャップ領域で、SSBW（Surface Skimming Bulk Wave）が発生するためと考えられる。すなわち、SSBWが上記ギャップ領域で発生する影響で、共振モードのレベルが減衰するためである。

【0034】上記SSBWは自由表面において強く放射されることが知られている。そこで、IDT電極においては、上記自由表面に相当する非励振領域を小さくすることで、上記SSBWの発生を抑えることが可能となる。

【0035】ここで、図1に示すように、IDT電極3における電極指32の先端と、それに対向するバスバー31との間のギャップ領域30は、励振には寄与していない自由表面となっている。それゆえ、上記ギャップ長Gを短くすれば、ギャップ領域30が狭くなるため、非励振領域を小さくすることができる。その結果、通過帯域内における平坦性を改善することができ、過剰狭帯域化現象を防止することが可能となる。

【0036】後述する実施例から明らかなように、実際に、上記ギャップ長Gと帯域内偏差（リップル偏差）および通過帯域の幅（帯域幅）との相関関係を得たところ、弾性表面波の波長を λ とした場合、上記ギャップ長Gを 0.3λ 以下に規定すれば、帯域内偏差および帯域幅が改善されることが見出された。上記リップル偏差は平坦性の指標であり、この値が小さいほど平坦性が良好となる。本発明では、ギャップ長Gを $0.3\lambda \leq G$ となるように規定すると、リップル偏差が改善され、帯域幅も広くなることがわかった。

【0037】なお、ギャップ長Gは上限として 0.3λ のみ規定されており、下限が規定されていないが、これは、上記ギャップ長Gが、飽くまで、電極指32の先端とバスバー31との間隔を指すものであり、常に0を超える（ $G > 0$ ）ので、下限を限定する必要がないためである。

【0038】すなわち、本発明では、ギャップ長Gの上限値は 0.3λ となっているのに対し、ギャップ長Gの下限値は、上記IDT電極3を形成する際のプロセス上の限界値に相当することになる。たとえば、IDT電極3を形成する方法としては、一般的にウエットエッチング法を用いることができるが、ドライエッチング法を用いることも可能である。このとき、ドライエッチング法で得られるギャップ長Gの限界値は、ウエットエッチング法で得られるギャップ長Gの限界値よりも小さくなる。したがって、ギャップ長Gの下限は、IDT電極3を形成するプロセスの限界値となる。

【0039】本発明では、さらに、図3に示すように、IDT電極3は、さらに、上記対向方向に向かって突き

出しており、相手方のバスバー 31 から延長される上記電極指 32 に対向するように形成される複数のダミー電極指 33... を有していてもよい。すなわち、ダミー電極 33 は、バスバー 31 から、非励振領域であるギャップ領域 30 に対して突出するように形成されていることになる。

【0040】このように、上記電極指 32 に対向するダミー電極指 33 を設けると、後述する実施例から明らかなように、上記平坦性の悪化をより一層確実に回避でき、過剰狭帯域化現象の発生をより効果的に防止することが可能となっている。

【0041】なお、ダミー電極指 33 が有る場合のギャップ長 G は、図 3 に示すように、電極指 32 の先端から、それに対向するダミー電極指 33 の先端までの間隔を指すものとする。それゆえ、ダミー電極指 33 の長さ、上記ギャップ長 G および IDT 電極 3 のサイズなどによって適宜選択される設計事項であり、特に限定されるものではない。

【0042】本発明では、圧電基板として上記回転 Y カット X 伝搬 LiTaO₃ 基板 2 が用いられる。この回転 Y カット X 伝搬 LiTaO₃ 基板 2 としては、具体的には、特に限定されるものではない。後述する実施例では、回転 Y カット X 伝搬 LiTaO₃ 基板 2 のカット角は、36° 回転 Y カット X 伝搬のものが用いられているが、これ以外のカット角を用いても、物性上の差異は SSBW の放射には関与しないため、同様の効果を得ることができる。

【0043】〔実施例〕本実施の形態における上記ギャップ長 G の規定について、以下の実施例に基づいてより具体的に説明する。なお、本実施例は、上記ギャップ長 G を規定するための一例であって、本発明はこの実施例に限定されるものではない。

【0044】本実施例では、上述した 2 段構成の縦結合型フィルタ 1 (図 2 参照) を例に挙げて説明する。本実施例で用いた縦結合型フィルタ 1 の基本的な構成は、次のようになっている。

【0045】すなわち、まず、縦結合型フィルタ 1 における通過帯域の中央となる中心周波数は、298MHz とした。また、圧電基板としては、36° 回転 Y カット X 伝搬 LiTaO₃ 基板 2 を用いた。電極材料としては Al-Cu 合金を用い、電極膜厚を 400nm とした。上記リフレクタ 4 の具体的な構成は、何れも、本数が 41 本で波長を 13.82 μ m とした。また、上記 IDT 電極 3 の具体的な構成は、図 2 に示す 3 個の IDT 電極 3a・3b・3c における電極指 32・32 の対数が、それぞれ 17 対、22 対、17 対となるように形成した。

【0046】次に、本実施例で用いられる、本発明にかかる縦結合型フィルタ (本発明型フィルタ) では、弾性表面波の波長を λ とした場合に、ギャップ長 G を 0.3

λ 以下となる ($0.3\lambda \geq G$) ように小さく設定している。さらに、本実施例では、比較のために、従来と同様に、ギャップ長 G を小さく設定しない従来の縦結合型フィルタ (従来型フィルタ) も用いている。この従来型フィルタとしては、基本的な構成は本発明型フィルタと同じであるが、ギャップ長 G を 0.46 λ ($G=0.46\lambda$) に設定している。

【0047】上記本発明型フィルタと、従来型フィルタとのそれぞれについて、その伝送特性を比較した。その結果を図 4 および図 5 に示す。なお、図 4 および図 5 の伝送特性を計測した本発明型フィルタでは、そのギャップ長 G を 0.2 λ に設定している ($G=0.2\lambda$)。また、図 4 および図 5 においては、実線が本発明型フィルタの、点線が従来型フィルタの伝送特性を示し、それぞれ①・②で示す。さらに、図中縦軸が挿入損失を、横軸が周波数を示す。

【0048】図 4 は、上記各フィルタの伝送特性を単純に計測したものである。図 4 から明らかなように、本発明型フィルタでは、従来型フィルタと比較して、通過帯域以外の特性を変えずに、帯域内の伝送特性の先細り傾向が解消されて、平坦性を改善することができることが分かる。

【0049】一方、図 5 は、共振モードの位置とレベルとを明確にするために、上記各フィルタにおいて、故意に外部回路との整合を外した上で、伝送特性の波形を計測したものである。図 5 の結果から明らかなように、共振モードのレベルを見ると、従来型フィルタに比べて、本発明型フィルタでは、ピークレベルが上昇している。したがって、従来の構成よりもギャップ長 G を小さくすることが、平坦性向上に寄与していることがわかる。

【0050】次に、上記ギャップ長 G と通過帯域内における平坦性との関係について定量的に評価した結果を以下に示す。

【0051】まず、上記基本構成の縦結合型フィルタにおいて、ギャップ長 G を変化させた場合に、上記平坦性の指標となる、ギャップ長 G に対するリップル偏差 (帯域内偏差) の変化について計測した。その結果を図 6 に示す。なお、図 6 では、正方形の黒ドットがダミー電極指 33 が無い場合 (図 1 の構成) の縦結合型フィルタであり、菱形の黒ドットがダミー電極指 33 が有る場合 (図 3 の構成) の縦結合型フィルタである。また、縦軸が帯域内偏差 (単位 dB) を示し、横軸がギャップ長 G (λ 基準) を示す。さらに、ダミー電極指 33 の長さは、本実施例では、約 2 λ となっている。

【0052】図 6 の結果から明らかなように、ギャップ長 G が 0.3 λ 以下となっていれば、リップル偏差の値は十分小さくなっていることがわかる。特に、ダミー電極が有る場合の縦結合型フィルタでは、0.3 $\lambda \geq G$ を満たすことによって、リップル偏差が十分に低下していることが非常に明確となっている。

【0053】次に、上記基本構成の縦結合型フィルタにおいて、ギャップ長 G を変化させた場合に、ギャップ長 G に対する通過帯域の幅（帯域幅）の変化について計測した。その結果を図7に示す。なお、図7でも、正方形の黒ドットがダミー電極指33が無い場合（図1の構成）の縦結合型フィルタであり、菱形の黒ドットがダミー電極指33が有る場合（図3の構成）の縦結合型フィルタである。また、縦軸が帯域幅（単位MHz）を示し、横軸がギャップ長 G （ λ 基準）を示す。

【0054】図7の結果から明らかなように、ギャップ長 G が 0.3λ 以下となっていれば、十分良好な帯域幅を得ることができる。これに対して、ギャップ長 G が 0.3λ を超えると帯域幅が急激に減少してしまい、過剰狭帯域化現象が生じることがわかる。そのため、 $0.3\lambda \geq G$ を満たさなければ、縦結合型フィルタとしての十分なフィルタ特性を得ることができなくなる。

【0055】さらに、図6および図7の比較から明かなように、リップル偏差の値が大きいと、平坦性が悪くなり、過剰狭帯域化現象が生じるが、上記ギャップ長 G を 0.3λ 以下に設定すれば、リップル偏差が改善され、通過帯域の幅が十分に確保され、過剰狭帯域化現象の発生を防止することが可能になる。

【0056】このように、本発明では、回転YカットX伝搬LiTaO₃基板上に、複数のIDT電極を一行に配置し、さらにこれを挟持するようにリフレクタなどの反射構造体を配置した縦結合共振子型の弾性表面波フィルタにおいて、IDT電極における電極指の先端とバスター（電極端子）との間のギャップ長 G を 0.3λ 以下に設定している。そのため、通過帯域内における平坦性を向上させ、過剰狭帯域化現象の発生を確実に防止することができる。

【0057】〔実施の形態2〕本発明の第2の実施の形態について図8および図9に基づいて説明すれば、以下の通りである。なお、本発明はこれに限定されるものではない。また、説明の便宜上、前記実施の形態1で使した部材と同じ機能を有する部材には同一の番号を付記し、その説明を省略する。

【0058】本実施の形態では、前記実施の形態1における縦結合型フィルタ、または、これを備える弾性表面波装置を通信装置に応用した例についてより具体的に説明する。

【0059】図8に示すように、本実施の形態における通信装置100は、具体的には、受信を行うレシーバ側（Rx側）として、アンテナ101、アンテナ共用部/RFTOPフィルタ102、アンプ103、Rx段間フィルタ104、ミキサ105、1stIFフィルタ106、ミキサ107、2ndIFフィルタ108、1st+2ndローカルシンセサイザ111、TCXO（temperature compensated crystal oscillator（温度補償型水晶発振器））112、デバイダ113、ローカルフィ

ルタ114を備えている。

【0060】また、上記通信装置100は、送信を行うトランシーバ側（Tx側）として、上記アンテナ101および上記アンテナ共用部/RFTOPフィルタ102を共用するとともに、TxIFフィルタ121、ミキサ122、Tx段間フィルタ123、アンプ124、カップラ125、アイソレータ126、APC（automatic power control（自動出力制御））127を備えている。

【0061】そして、上記のRx段間フィルタ104、1stIFフィルタ106、TxIFフィルタ121、あるいはTx段間フィルタ123には、上述した実施の形態1の縦結合型フィルタまたはこれを備える弾性表面波装置を好適に用いることができる。

【0062】このように、本実施の形態における上記通信装置は、前記実施の形態1の弾性表面波フィルタ（縦結合型フィルタ）、またはこれを備える弾性表面波装置を用いている。上記弾性表面波フィルタは、非常に良好な伝送特性を備えているので、上記構成の通信装置は、良好な送受信機能と共に小型化、特にGHz帯域以上において小型化を図れるものとなっている。

【0063】また、本実施の形態の他の例として、上記縦結合型フィルタ、または、これを備える弾性表面波装置を、RKE（Remote Keyless Entry System）のRF用フィルタに用いる例を挙げることができる。

【0064】すなわち、図9に示すように、本実施の形態におけるRKE200は、アンテナ201、RxTOPフィルタ202、アンプ203、ミキサ204、1stIFフィルタ205、1stローカルフィルタ206等を備えているが、このうち、特に、上記RxTOPフィルタ202には、上述した実施の形態1の縦結合型フィルタまたはこれを備える弾性表面波装置を好適に用いることができる。

【0065】

【発明の効果】以上のように、本発明にかかる弾性表面波フィルタは、縦結合共振子型の弾性表面波フィルタにおいて、圧電基板として回転YカットX伝搬LiTaO₃基板を用いるとともに、一方の電極端子が有する上記電極指の先端と、これに対向する他方の電極端子との間隔をギャップ長 G とし、上記弾性表面波の波長を λ とした場合に、 $0.3\lambda \geq G$ の関係が成立する構成である。

【0066】上記構成によれば、上記ギャップ長 G を、弾性表面波の波長 λ の0.3倍よりも短くすれば、自由表面に相当する非励振領域を小さくすることができるので、SSBWの発生を抑えることが可能となる。そのため、通過帯域内における平坦性の悪化を回避し、過剰狭帯域化現象の発生を効果的に防止することができる。その結果、高いフィルタ特性を有する弾性表面波フィルタを得ることができるという効果を奏する。

【0067】本発明にかかる弾性表面波フィルタは、上記構成に加えて、上記電極端子が、さらに、上記対向方

向に向かって突き出すことにより、相手方の電極端子から延長される上記電極指に対向するように形成される複数のダミー電極指を有する構成である。

【0068】上記構成によれば、上記電極指に対向するように、ダミー電極指を設けることによって、上記SSBWの発生をより一層抑えることが可能となる。そのため、上記平坦性の悪化を回避し、過剰狭帯域化現象の発生を効果的に防止することができる。その結果、より一層高いフィルタ特性を有する弾性表面波フィルタを得ることができるという効果を奏する。

【0069】本発明にかかる弾性表面波装置は、上記構成の弾性表面波フィルタを備える構成である。

【0070】また、本発明にかかる通信装置は、上記構成の弾性表面波フィルタ、または上記構成の弾性表面波装置を用いる構成である。

【0071】上記各構成によれば、高品質の弾性表面波フィルタを備えているため、弾性表面波装置または通信装置としての機能をより一層向上させることができるという効果を奏する。

【図面の簡単な説明】

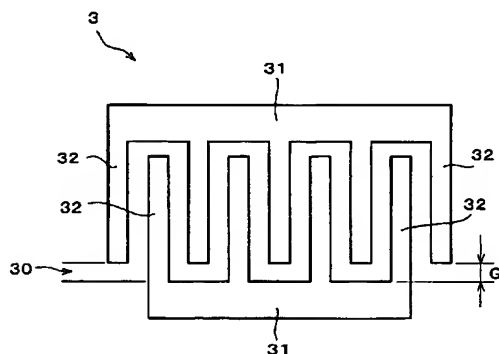
【図1】本発明にかかる弾性表面波フィルタに含まれるIDT電極の概略構成を示す平面図である。

【図2】図1に示すIDT電極を含む、本発明にかかる弾性表面波フィルタの概略構成の一例を示す平面図である。

【図3】図1に示すIDT電極の他の構成を示す概略平面図である。

【図4】本発明にかかる弾性表面波フィルタにおける伝送特性と、従来の弾性表面波フィルタにおける伝送特性とを比較するグラフである。

【図1】



【図5】本発明にかかる弾性表面波フィルタにおける伝送特性と、従来の弾性表面波フィルタにおける伝送特性とを比較するグラフであり、整合を外した状態で得られた伝送特性を示すグラフである。

【図6】本発明にかかる弾性表面波フィルタにおいて、ギャップ長Gに対する帯域内偏差の関係を示すグラフである。

【図7】本発明にかかる弾性表面波フィルタにおいて、ギャップ長Gに対する通過帯域の幅の関係を示すグラフである。

【図8】本発明にかかる通信装置の要部ブロック図である。

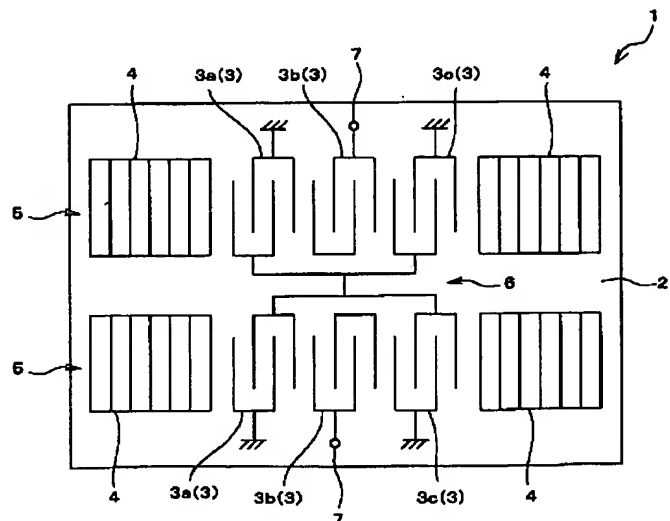
【図9】本発明にかかる通信装置の他の例としての、RKEの要部ブロック図である。

【図10】従来の構成の縦結合型フィルタの伝送特性を示すグラフである。

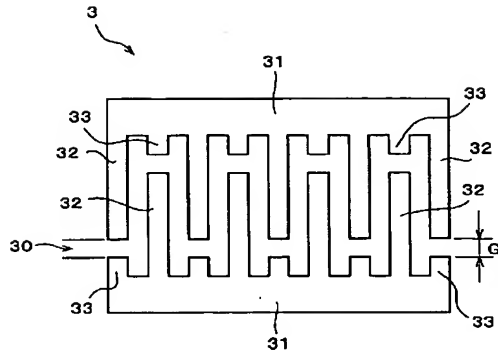
【符号の説明】

- 1 縦結合共振器型の弾性表面波フィルタ（縦結合フィルタ）
- 2 回転YカットX伝搬LiTaO₃基板
- 3 インターデジタルトランスデューサ電極（IDT電極）
- 4 反射器
- 31 バスバー（電極端子）
- 32 電極指
- 33 ダミー電極指
- G ギャップ長
- 100 通信装置
- 200 RKE（通信装置）

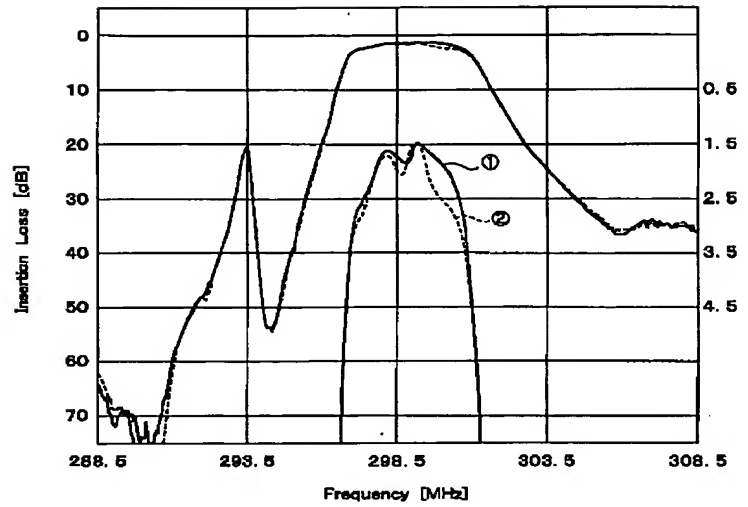
【図2】



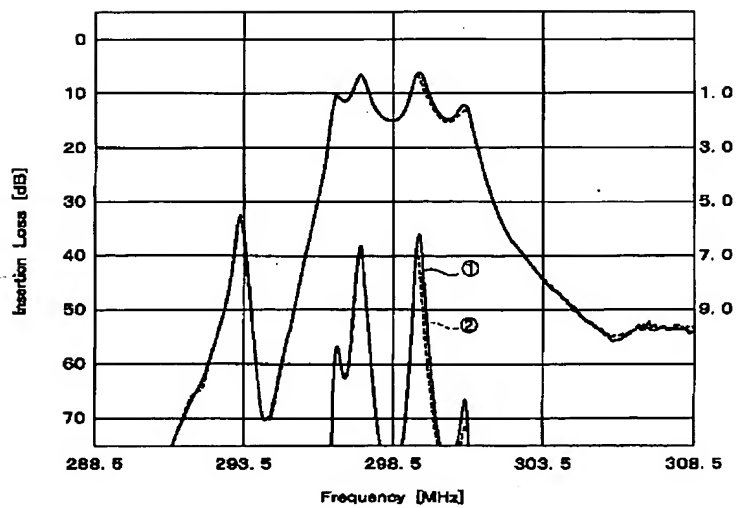
【図 3】



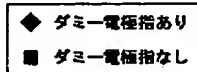
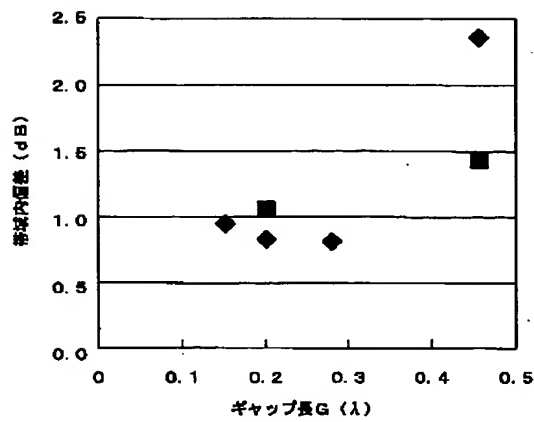
【図 4】



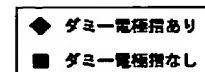
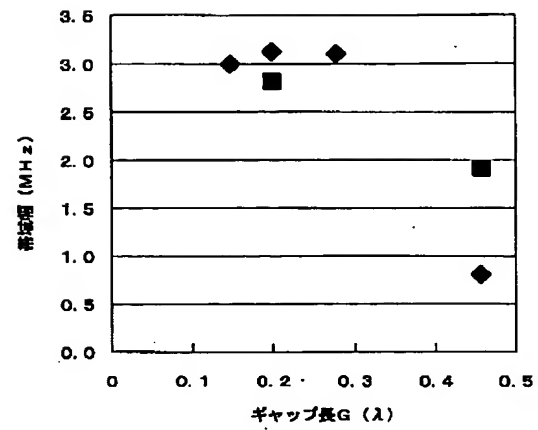
【図 5】



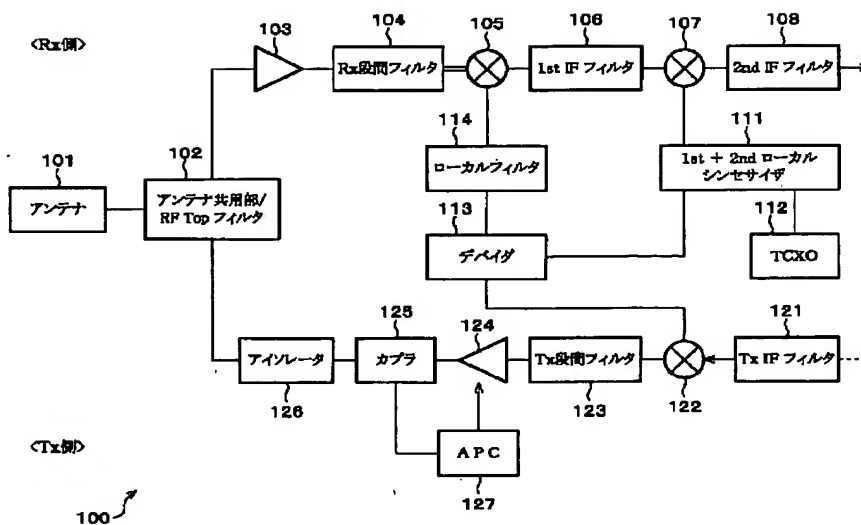
【図 6】



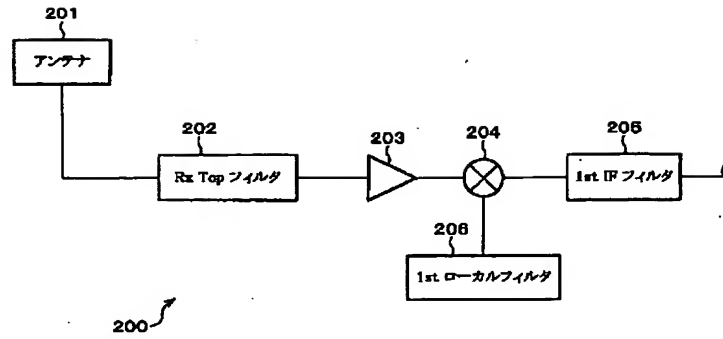
【図 7】



【図 8】



【図 9】



【図 10】

